OPERANT ASSESSMENT OF VISUAL ACUITY IN THE PROFOUNDLY RETARDED

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by

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An abstract of a Thesis by
Debra J. Kitzman
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The problem. Traditional subjective visual acuity tests are not effective in testing nonverbal, profoundly retarded individuals. The present paper investigated the use of operant conditioning procedures in determining threshold crossings and compared the effectiveness of the staircase and descending series stimulus presentation methods, using a two-response paradigm.

Procedure. Three profoundly retarded and two mildly retarded individuals were trained to discriminate between a right-facing E and an upward-facing E, using stimulus fading and reinforcement procedures. The participants indicated the presence of a given stimulus by responding on one of two levers or drawing the E as displayed. Correct responses resulted in praise and an edible reinforcer. Incorrect responses were followed by a 10 second time-out and the reinforcer was withheld.

Findings. Correct responses reached the established criterion during the right-facing E versus blank card condition only after the implementation of instructions and time-out procedures. The upward-facing E was faded onto the blank card and the distance from the participants was increased to ten feet without significant difficulties. The threshold crossings obtained with three participants were reliable within and across the type of stimulus presentation method used. The threshold crossings produced with the staircase method were similar to or lower than those produced with the descending-series method. The threshold estimations obtained with the present procedures were similar to or lower than those obtained by an ophthalmologist using the Snellen chart.

Conclusions. The instructions and time-out procedures appeared to be significant variables in obtaining stimulus control over responding. The present procedures must be further refined before application to applied settings due to the extended time spent in training.

Recommendations. Procedures for testing visual acuity in the profoundly retarded must include a means to promote attention to the stimuli. Future research should investigate the significance of simple instructions and time-out procedures and testing between sessions (Test B) in visual acuity assessments.

ACKNOWLEDGEMENTS

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I would also like to thank my friends and co-workers at Woodward State Hospital-School for their support and encouragement; the names are too numerous to mention. A special thanks to Dr. Rudolpho Legislador for providing me with literature on visual acuity assessments with the mentally retarded, to Richard Powell for wiring the electronic equipment, and to Thomas Dougherty and Duane Dolphin for reminding me of my goals when I was discouraged.

To my mother, Joanne M. Dickenson, and my grandparents, Floyd and Iva Mae Winters, I owe the most for their continuous support and encouragement throughout my education. Without them, this major goal of my life may never have been achieved. The only regret is that my grandfather, Floyd A. Winters, is not alive to see my achievement. He spent his life helping others, especially children, and devoting love to his family and friends. Because he will always be deeply missed, I dedicate this thesis to him.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The American Association of Ophthalmology estimates that 80-85% of a person's learning is through the visual pathway. Therefore, visual screening is extremely necessary in order to correct visual deficits that may inhibit learning. A profoundly retarded client is unable to understand complex instruction, and therefore, unable to emit the required responses necessary for the present subjective visual screening procedures. Because most profoundly retarded individuals are untestable with traditional subjective methods, many may not receive a complete visual screening.

One survey of institutionalized retarded individuals found that 50-68% of this population required the services of an ophthalmologist (Evans, Wachs, & Barger, 1972). This percentage is significantly greater than that of the normal population. Since this population is more susceptible to visual disorders and suffers from various learning handicaps, correction of visual disorders may enhance learning. Approximately 40% of the subjects in one study demonstrated improvements in behavior once visual deficits were corrected (Fletcher & Thompson, 1961).

Every effort should be made to provide the mentally retarded individual with an environment that facilitates

learning. This includes the development of proper visual screening procedures in order to detect and provide the necessary corrections of visual problems. "The efforts expended in improving the eye health of this population is well spent if it results in the individual's ability to see better, feel better, look better, or function at a higher level" (Blackhurst & Radke, 1968, p. 84).

A basic eye examination includes objective and subjective measures of the eye. An objective measure includes an assessment of the pupil dilation, ascular motility and alignment, refraction, general external examination, and an ophthalmosopic examination of the internal eye. Many eye disorders are detected through these examinations.

A subjective measure is visual acuity. Visual acuity is the precision in which an observer can see fine details and depends upon the ability of the eye to resolve a given visual angle. Most tests vary the angle by changing either the size of the stimuli or its distance from the eye. Results of visual acuity are recorded as a fraction with the numerator representing the distance from the stimulus to the observer and the denominator representing the minimum visual angle perceived by the observer. The standard distance used for visual acuity assessments is twenty feet. A visual acuity of 20/20 indicates that the observer recognized the stimulus whose lines subtend 1' of

arc at a distance of 20 feet.

Several types of visual acuity may be measured depending upon the specific task or detail to be resolved (see Appendix A). The most familiar visual acuity task is recognition. This task assesses the observer's ability to recognize and name various sized letters or symbols. The smallest recognizable symbol indicates the minimum angle of detail that can be resolved.

A variety of recognition tasks have been developed of which the Snellen charts are the most common. The charts are composed of rows of letters or symbols in progressively smaller sizes. The Snellen "tumbling E" chart contains all Es and the observer indicates the orientation of the legs. Typically, this chart is applied to illiterate adults or young children.

Since the profoundly retarded population does not possess the necessary language skills or understand the instructions required for such tests, reliable and accurate subjective visual acuity assessment techniques need to be developed. Although most research has been conducted with nonhuman participants, e.g., pigeons (Blough, 1971), bats (Dallard, 1970), goldfish (Yager & Thorpe, 1970), and cats (Berkley, 1970), operant procedures have been developed to assess visual (Macht, 1970, 1971; Newsom & Simon, 1977) and auditory (Fulton & Spradlin, 1974a, 1974b; Springer, 1980; Woolcock & Alferink, 1982) thresholds in human participants.

The research paradigms mentioned may be differentiated according to response requirements and psychophysical stimulus presentation methods. The response requirement may involve one, two, or multiple response operanda (see Appendix B). A single response operandum, used to assess auditory thresholds for profoundly retarded persons, failed to establish stimulus control in all participants (Woolcock & Alferink, 1982). The participants were reinforced for responding on the operandum only during tone presentations. In order to provide an alternative response during the no-tone presentations, two responses have been used (Springer, 1980). In this forced choice paradigm, the participants indicated the presence of the tone by responding on one operandum and the absence of tone by responding on the second.

A response requirement similar to Woolcock and Alferink (1982) was used in the assessment of subjective visual acuity for nonverbal children (Macht, 1970, 1971). A lever press indicated the presence of the right-facing E. No responses indicated the presence of the left-facing E. In addition, the forced choice paradigm has been applied to visual acuity assessments (Newsom & Simon, 1977). The participants were required to touch the downward-facing E which was simultaneously presented with the left-facing E. The researchers reported difficulties in obtaining stimulus control with the lower functioning

participants in the study and blamed the stimulus discrimination training method. The left-facing E was gradually made brighter on an initially blank card. This required the participants to transfer stimulus control from brightness to letter orientation. An alternative explanation may be a complex response requirement. Participants in a sitting position were required to walk around a table and touch the correct stimulus. A simple lever press, such as described by Springer (1980), may facilitate discrimination training.

The descending series of limits and the "tracking" or staircase method of limits are the most common psychophysical stimulus presentation methods used (see Appendix C). In the descending series method, the researcher begins with a stimulus value that has a high probability of detection. Over succeeding trials, the stimulus value is reduced until the participant responds incorrectly. Given an error, the stimulus is returned to the initial value or to a value that is readily detectable.

With the staircase method, the stimulus value is presented in sequential order, but the direction of the stimulus change is dependent upon the participant's response. Each correct stimulus detection is followed by a standard decrease in the stimulus value, while each error results in a standard increase in the stimulus value. An advantage of the staircase method of limits is that most of

the trials are near the threshold level (Cornsweet, 1962).

Both psychophysical stimulus presentation methods have been used for the audiometric assessment of nonverbal retarded individuals (Springer, 1980; Woolcock & Alferink, 1982). The threshold measurements produced by the staircase method were equal to or slightly lower than thresholds produced by the descending series method. No comparison between psychophysical stimulus presentation methods have been conducted within the visual acuity assessments. Only the staircase method was used by Macht (1970, 1971) and Newsom and Simon (1977). In addition to a simple response requirement, retarded participants may benefit from a stimulus fading procedure (Sidman & Stoddard, 1966; Terrace, 1963). This procedure involves the progressive introduction of the second stimulus. Research has demonstrated that errors create more errors and has emphasized the importance of reducing fading steps should errors occur.

To assess the visual acuity of retarded individuals, the present study used a two-response forced-choice procedure. Participants were trained to discriminate between upward-facing and right-facing Es. Thresholds obtained with the descending series and the staircase methods were compared. Five participants were tested; three were experimental participants and two were used to compare the operant procedures with the traditional Snellen chart procedures.

CHAPTER II

METHOD

Participant Selection

Three profoundly retarded and two mildly retarded adults residing in a state institution for the mentally retarded participated. Participant selection was based upon the following criteria. All participants could complete various table activities for at least five minutes. The profoundly retarded adults had limited or no expressive language skills and had no severe inappropriate behavior that interferred with testing. The mildly retarded participants had complex expressive and receptive language skills to respond to the experimental task.

Apparatus

A 40 cm x 10 cm x 10 cm human operant conditioning console was on a table located in a 3.6 m x 5.3 m room. The front panel of the console contained two sponge mop levers (Bijou, 1957; Bijou & Baer, 1967) spaced 20 cm apart. The participants sat on a chair located directly behind the console.

A Davis Scientific Instruments (DSI) M&M dispenser (model no. MMD-2) located in a small box (20.5 cm x 30 cm x 30 cm) adjacent to the console delivered M&Ms through a 1.5 cm x 15.0 cm tube into a small plastic tray.

Two sets of 18 cm^2 stimulus cards were used; one for

training and one for testing visual acuity. The cards were made of white posterboard material and the stimuli, centered upon the cards, were made of black construction paper. The training cards (see Figure 1) contained one right-facing E (S6), representing the 10/800 visual acuity ratio, one blank card (S1), and four cards with gradually more bars of the upward-facing 10/800 E (S2-S4). Since the testing distance was 10 feet, the testing cards displayed Es which represented visual acuity ratios of 10/400, 10/200, 10/160, 10/140, 10/120, 10/80, 10/60, 10/40, 10/20, and 10/10. Each letter was constructed so that the line thickness was one-fifth the height of the letter. To convert the above ratios for 20 feet, the denominator was multiplied by two. Thus, the 10/400 E and the 20/800 E were the same size, but were presented at ten and twenty feet respectively.

A control card, which displayed a 8.7 cm square with the similar proportions of black and white as an E, was designed. A table of random numbers was used to randomly position the black and white upon the control card.

The cards were placed in a 20 cm^2 easel positioned in the middle of the console. As the study progressed, the easel was relocated to the center of a 50 cm x 60 cm desk. Paper and a pencil were used with the third participant.

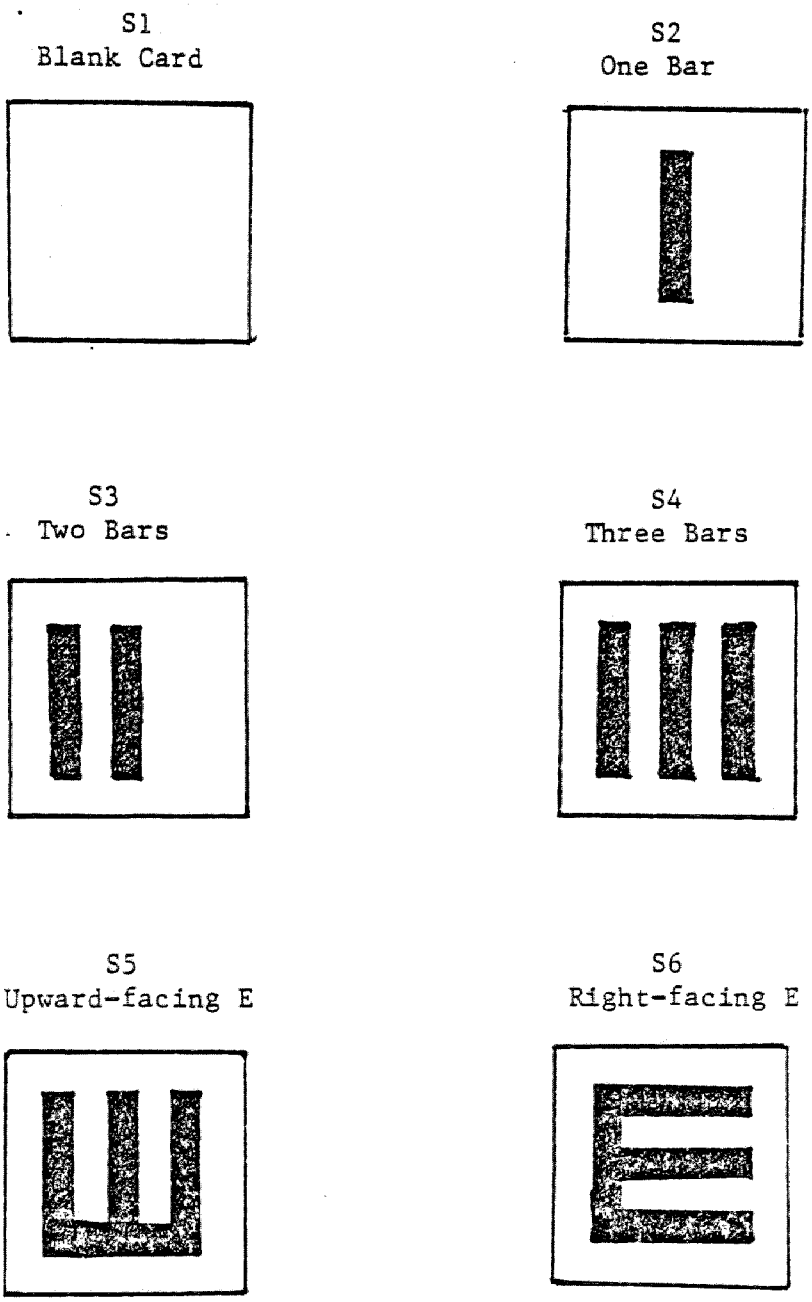

Figure 1. Stimulus cards used in training and testing.

Individual Participants and Procedures

Each participant and each procedure are described together.

Participant 1

Participant 1, a twenty-one year old male, was diagnosed as mentally retarded due to unknown cause and functioned within the profound range of mental retardation, intellectually and adaptively, according to American Association on Mental Deficiency standards.

Participant 1 had functional comprehension skills, but minimal expressive language. He used single words that were understandable in context, but his spontaneous remarks were frequently jargon. He named familiar objects, but did not read or write. He completed most basic self-help skills, but required prompts for all refined self-help skills.

He was last seen by an ophthalmologist eight months prior to the presented procedures. The examination indicated normal eyes with a visual acuity estimation at 20/30. The refractive error was not provided.

Training Procedures for Participant 1

Pretraining

Magazine Training: During one 20-minute session while seated in a chair at a table in the experimental room, the participant learned to pick up the edible reinforcer from the tray within 5-10 seconds after delivery.

Lever-press Training: The participant was manually prompted to press the two levers in an unsystematic order. The reinforcer was dispensed immediately following each response. Prompts were faded over three sessions as independent responding developed. Only the right-facing E was in the easel for five sessions. Responses on the right lever were continuously reinforced until 80% correct responses for two consecutive sessions was achieved.

Discrimination Training

Right-facing E (S6) versus Blank Card (S1): The right-facing E and the blank card were presented randomly for six sessions. Each correct response on the left lever or on the right lever in the presence of the right-facing E or the blank card, respectively, resulted in one reinforcer. Each stimulus was presented for approximately thirty seconds or until an error occurred. Following an error, the stimulus was removed and presented again; the participant was physically prompted to respond on the correct lever. The correction trial ended following a correct response. Stimulus presentations were separated by a ten second intertrial interval. Responses during the interval resulted in a ten second delay of the next trial. Each session ended upon the participant receiving approximately 40 reinforcers.

Right-facing E (S6) versus One Bar (S2): During the next thirty-three sessions, the one bar card replaced the blank card. All other procedures remained in effect.

Easel Movement: At the beginning of each trial, the easel was positioned directly over the correct lever instead of centered on the console. In the next eight sessions, the easel was moved toward the center of the console in four centimeter steps.

Reinforcement Schedule: When the participant was responding above 80% correct for at least two consecutive sessions, the reinforcement schedule was changed so that two correct responses (Fixed Ratio 2) on the right lever in the presence of the right-facing E or on the left lever in the presence of the one bar produced one reinforcer. This schedule was in effect for the duration of the study.

Easel Movement: For seven sessions, easel movement was again implemented, as described above.

Upward-facing E (S5) Probe Sessions: For eight consecutive sessions, the upward-facing E replaced the one bar.

Time-out: At the beginning of each stimulus presentation, the experimenter provided the instruction, "(Participant name), look at the card. Which lever?" Each stimulus was presented for approximately thirty seconds or until an error occurred. Errors were followed by a verbal "No," stimulus removal, and a brief ten second time-out.

During the time-out period, responses on either lever resulted in another ten seconds delay. After the time-out, the stimulus was presented again and the trial ended following a correct response. The time-out procedures were implemented for the duration of the study.

Physical Prompts: The experimenter physically prompted Participant 1 to press the lever over which he held his hand for at least 5 seconds and the appropriate consequence was provided. Physical prompts were faded using graduated guidance techniques.

Right-facing E (S6) versus Blank Card (S1): The blank card was reintroduced in place of the upward-facing E for seven consecutive sessions.

Pop: Participant 1 continued to receive an M&M after correct responses, but soda pop was provided at the end of each correctly completed trial. This change was maintained for the duration of the study.

Fading the Upward-facing E (S5): Each bar that comprised the upward-facing E was gradually introduced onto the blank card. The order was the middle vertical bar (S2), the left vertical bar (S3), the right vertical bar (S4), and the bottom horizontal bar (S4). Each stimulus condition was introduced after the participant responded above the criterion on each lever for two consecutive sessions.

Distance Training

The distance from the participant to the easel increased gradually until the easel was ten feet away. The easel was moved two, six, and ten feet away. Prior to advancing the distance, the participant was required to maintain correct responses to each stimulus above the criterion for two consecutive sessions.

Testing Procedures for Participant 1

Testing Between Sessions (Test B)

The size of the right-facing (S6) and upward-facing (S6) Es was reduced each session until the Es representing the visual acuity ratios of 10/800, 10/400, 10/200, 10/120, 10/80, 10/60, 10/40, 10/20, and 10/10 were presented.

Testing Within Sessions (TestW)

The 10/400 E was presented randomly in the right-facing (S6) and upward-facing (S5) positions. The procedures described under time-out were used during Test W. Two correct responses (Fixed Ratio 2) on the right lever in the presence of the right-facing E or on the left lever in the presence of the upward-facing E resulted in one reinforcer.

Stimulus Presentation Methods

Descending Series Method: The stimulus size was reduced following each correct trial until an error occurred. In the ensuing trial, the 10/400 E was presented

for a second descending series. Each session was terminated after at least two descending threshold crossings were obtained or after 40 reinforcers were delivered.

Staircase Method: Each correct trial was followed by a trial with a reduction in the stimulus size and each trial with an error was followed by a trial with an increase in the stimulus size. Sessions were terminated after two threshold crossings were accomplished or after 40 reinforcers were delivered.

Order of Application: The stimulus presentations methods were alternated each session for four sessions. The descending series method was used during the first and third testing sessions; the staircase method was used during the second and fourth testing sessions.

Reversal to Training Conditions

The participant was randomly presented with the 10/800 Es in right-facing and upward-facing positions from ten feet. When the participant maintained correct responses to each stimulus above the criterion for two consecutive sessions, Test W was conducted for two consecutive sessions.

Testing Procedures for Participant 1

Testing Within Sessions (Test W)

Testing within sessions (Test W) and stimulus presentation methods remained the same as previously

described. Test W was conducted in two sessions: the first session using the descending series and the second session using the staircase method.

Control Card

The control card was presented randomly in two positions for two consecutive sessions. The participant was provided with a reinforcer for two correct responses on the left lever when the card was in one position or on the right lever when the card was in another position. Sessions were terminated after the 40th reinforcer.

Testing Procedures for Participant 1

Testing Within Sessions (Test W)

Testing within sessions (Test W) and stimulus presentation methods remained the same as previously described. Test W was conducted in four sessions: the staircase method was used in the first and fourth testing sessions and the descending series method was used in the second and third testing sessions.

Participant 2

Participant 2, a thirty-year-old male, was diagnosed as mentally retarded associated to birth trauma and functioned within the profound range of mental retardation intellectually and the severe range of mental retardation adaptively, according to American Association on Mental Deficiency standards.

Participant 2 was able to speak in short phrases and single word utterances, and make simple requests for most

items desired. He was able to follow simple, routine instructions and retrieve common objects when named. He did not read or write. He was independent in most basic self-help skills, but required prompts to complete all refined self-help skills.

Participant 2 was last examined by an ophthalmologist six years previously. The results indicated a hyperopic astigmatism with mild exotropia in the left eye. Based upon refractive error (Borish, 1975, p. 368), the visual acuity was estimated at 20/30.

Training Procedures for Participant 2

Pretraining

Magazine and lever-press training for Participant 2 were identical to those for Participant 1 with prompts faded over two sessions and the right-facing E presented alone in three sessions.

Discrimination Training

Right-facing E (S6) versus Blank Card (S1): The right-facing E and the blank card were presented randomly for four sessions. The procedures used were identical to those for Participant 1.

Right-facing E (S6) versus One Bar (S2): The one bar replaced the blank card in seven sessions. All other procedures remained in effect.

Upward-facing E (S5) Probe Sessions: The upward-facing E replaced the one bar in eight sessions to assess if Participant 2 discriminated the right-facing and upward-

facing Es.

Right-facing E (S6) versus One Bar (S2): The one bar was reintroduced for three sessions. All other procedures remained in effect.

Right-facing E (S6) versus Two Bars (S3): A card with the middle vertical bar and the left vertical bar of the upward-facing E replaced the one bar for eight sessions.

Upward-facing E (S5) Probe Sessions: The upward-facing E was reintroduced in the next nineteen session.

Reinforcement Schedule: Two correct responses (Fixed Ratio 2) on the right lever in the presence of the right-facing E or on the left lever in the presence of the upward-facing E produced one reinforcer.

Easel Movement: At the beginning of each trial, the easel was positioned directly over the correct lever instead of centered on the console. Over the next thirteen sessions, the easel was moved toward the center of the console in four centimeter steps.

Reinforcement Schedule: Three correct responses (Fixed Ratio 3) on the right lever in the presence of the right-facing E or on the left lever in the presence of the upward-facing E produced one reinforcer in the next ten sessions.

Right-facing E (S6) versus Blank Card (S1): The blank card was reintroduced in the place of the upward-

facing E in nine sessions.

Time-out: The time-out procedures were the same as those for Participant 1. These procedures remained in effect for the duration of the study.

Reinforcement Schedule: Four correct responses (Fixed Ratio 4) on the right lever in the presence of the right-facing E or on the left lever in the presence of the blank card produced one reinforcer during the next ten sessions.

Fading the Upward-Facing E (S5): This procedure was identical to that for Participant 1.

Reinforcement Schedule: Five correct responses (Fixed Ratio 5) on the right lever in the presence of the right-facing E or on the left lever in the presence of the upward-facing E produced one reinforcer for the remainder of the study.

Distance Training

The distance from the participant to the easel was increased gradually until the easel was ten feet away. The easel was moved two, four, six, eight, and ten feet away. After correct responses to each stimulus were maintained above the criterion for two consecutive sessions, the distance was changed.

Testing Procedures for Participant 2

Testing Between Sessions (Test B)

The size of the right-facing and upward-facing Es was reduced each session until the Es representing visual acuity ratios of 10/400, 10/200, 10/120, 10/80, 10/60, 10/40, 10/30, 10/20, and 10/10 were presented.

Testing Within Sessions (Test W)

Testing within sessions (Test W) and stimulus presentation methods were the same as those described for Participant 1. Each stimulus presentation method was applied for one session: first the staircase method, then the descending series method.

Reversal to Training Conditions

After two testing sessions, the easel was moved to the center of the console and the 10/800 E was presented in the right-facing and upward-facing positions during the next four sessions. After correct responses to each stimulus weremaintained above the criterion for two consecutive sessions, the distance was again increased, as described in the distance training.

Testing Procedures for Participant 2

Testing Within Sessions (Test W)

Testing within sessions (Test W) and stimulus presentation methods remained the same as those described for Participant 1. Each stimulus presentation method was applied for one session: first the staircase method, then

the descending series method.

Control Card

The control card was presented for two consecutive sessions, as described for Participant 1.

Testing Procedures for Participant 2

Testing Within Sessions (Test W)

Testing within sessions (Test W) and stimulus presentation methods remained the same as those described for Participant 1. The order of the stimulus presentation methods was reversed: in the first and fourth testing sessions, the descending series method was used and in the second and third testing sessions, the staircase method was used.

Participant 3

Participant 3, a thirty-four year old male, was diagnosed as mentally retarded due to unknown cause and functioned within the profound range of mental retardation intellectually and within the severe range of mental retardation adaptively, according to the American Association of Mental Deficiency Standards.

Participant 3 communicated with single words or phrases which were often echolalic. He printed his name and copied complex symbols, but did not read. He completed basic self-help skills independently, but required prompts for more refined self-help skills.

He was last seen by an ophthalmologist seven years

prior to the presented procedures. At that time, he had normal eyes with visual acuity estimation at 20/30. The refractive error had no power.

Phase I Training Procedures for Participant 3

Pretraining

Magazine and lever-press training for Participant 3 were identical to those for Participant 1 with prompts faded over two sessions and the right-facing E presented alone in four sessions.

Discrimination Training

Right-facing E (S6) versus Blank Card (S1): The right-facing E and the blank card were presented randomly for nineteen sessions. The procedures used were identical to those for Participant 1.

Stimulus Presentation Interval: The stimuli were presented for various durations during the first eight sessions. The duration was thirty seconds in session one, two minutes in sessions two and three, and one minute in sessions four through eight. After session eight, the stimuli were always presented for approximately thirty seconds.

Reinforcer Revisions: The reinforcer provided after a correct response was changed to jelly beans for three sessions, after which M&Ms were again used. In session 17, the experimenter began to provide praise in conjunction with the M&Ms. Praise was given whenever the participant initially chose the correct lever in the trial,

but not during the correction procedure. Praise and M&Ms were used for the remainder of the study.

Phase II Training Procedures for Participant 3

Discrimination Training

Right-facing E (S6) versus Upward-facing E (S5)

: Paper and a pencil were placed on the table directly in front of the participant. The experimenter pointed to the stimulus in the easel two feet away and provided the instruction: "(Participant Name), draw the E." Correct responses were immediately followed by the experimenter praising him and providing an M&M. Errors resulted in the card being removed for 10 seconds and presented again. Each trial ended upon the occurrence of one correct response. Each session ended upon the participant receiving 40 reinforcers. When the participant responded correctly for 80% of the trials within one session, distance training commenced.

Distance Training

The distance from the participant to the easel was gradually increased until the easel was 10 feet away. After each correct trial, the easel was moved away two feet. After each error, the easel was moved two feet toward the participant. When the participant responded correctly for 80% of the trials at a distance of ten feet within one session, testing was conducted.

Testing Procedures for Participant 3

Testing Within Sessions (Test W)

The testing procedures were the same as those described under right-facing E versus upward-facing E within Phase II. The stimulus presentation methods described under Participant 1 were used. Each stimulus presentation method was applied for two sessions: the staircase method used in the first and fourth sessions and the descending series method used in the second and third sessions. Three months after the participant was discontinued from the procedures, two follow-up sessions, one using the descending series method and one using the staircase method, were conducted.

Comparison of Operant Assessment Procedures with Traditional Snellen Charts

Participant 4, a twenty-four year old female, was diagnosed as mentally retarded due to postnatal cerebral infection and functioned within the mild range of mental retardation intellectually and adaptively, according to American Association on Mental Deficiency standards.

She demonstrated well-developed language skills ranging from 8-10 year age level. She understood abstract language and explained commonly used idioms. She read simple stories, wrote correspondence letters, and independently completed all basic and refined self-help skills.

Participant 4 was last seen by an ophthalmologist

eight months prior to the present study. The results indicated hyperopia astigmatism. Based upon refractive error (Borish, 1975, p. 368) and the Snellen chart, her visual acuity was estimated at 20/20.

Participant 5, a forty-year-old male, was diagnosed as mentally retarded due to prenatal injury and functioned within the mild range of mental retardation intellectually and adaptively, according to American Association on Mental Deficiency standards.

He demonstrated well-developed language skills at the 5 1/2 year age level. He understood abstract language and commonly used idioms. He read and wrote short notes and independently completed all basic and refined self-help skills.

Participant 5 was last seen by an ophthalmologist six months prior to the present study. The results indicated exotropia with 20/25 visual acuity via Snellen chart. The refractive error was not provided.

Training Procedures for Participants 4 and 5

Pretraining

Five minutes prior to the first session, the participants were instructed that five responses on the right lever in the presence of the right-facing E and on the left lever in the presence of the upward-facing E resulted in one reinforcer. The correct stimulus was displayed as the instructions were given.

Discrimination Training

Right-facing E (S6) versus Upward-facing E (S5): The 10/800 right-facing E and the 10/800 upward-facing E were presented randomly for five trials. Five responses on the right lever in the presence of the right-facing E and on the left lever in the presence of the upward-facing E resulted in one reinforcer. Each stimulus was presented for approximately thirty seconds or until an error occurred. Errors were followed by a verbal "No," stimulus removal, and a brief ten second time-out. During the time-out, responses on either lever resulted in the ten seconds restarting. After the time-out, the stimulus was presented again and the trial ended following the next correct response. Stimulus presentations were separated by a ten second intertrial interval. Responses during the interval resulted in a ten second delay of the next trial.

Testing Procedures for Participants 4 and 5

Testing Within Sessions (Test W)

Following the five sample trials, threshold testing was implemented using the same procedures. The 10/400 E was presented randomly in the right-facing or upward-facing positions. The size of the E was modified after each trial. Sessions were discontinued when 40 reinforcers were delivered or two threshold crossings were accomplished. Each participant was tested in two sessions.

Stimulus Presentation Methods

The stimulus presentation methods were the same as those for Participant 1. Participant 4 was tested in the first session using the staircase method; the second session using the descending series method. Participant 5 was tested in the first session using the descending series method; the second session using the staircase method.

Interobserver Reliability

Interobserver reliability was completed by a trained independent observer and the experimenter. The independent observer was stationed behind a partition away from the participant and the experimenter. The observer and the experimenter independently recorded the cumulative data from the digital counters after each trial and independently converted the cumulative data to frequency data for each trial. For Participant 3 in Phase II, the observer and the experimenter independently recorded whether or not the participant drew the correct stimulus in each trial. Reliability was calculated by dividing the number of agreements by the number of agreements plus disagreements multiplied by 100. Reliability was completed in three sessions for Participants 1 and 2, in five sessions for Participant 3, and in one session for Participants 4 and 5. Reliability scores varied from 92-100% for Participants 1, 2, 4, and 5 and varied from 66-100% for Participant 3. The 66% score was obtained during the first reliability session.

CHAPTER III

RESULTS

All participants reached the criterion of 80% correct for two consecutive sessions. Although, Participants 1, 2, and 3 required several procedural alterations. After the criterion was met, the visual acuity assessments were conducted.

Training Results for Participant 1

Pretraining

Data were not collected during pretraining.

Discrimination Training

Discrimination training required 65 sessions.

Right-facing E (S6) versus Blank Card (S1): Correct responses to the right-facing E varied from 76-88% and correct responses to the blank card varied from 55-81% (sessions 1-6). Figure 2B shows an increasing trend of correct responses to the blank card from 55% to 81% by session 5.

Right-facing E (S6) versus One Bar (S2): Percent correct responses in the presence of each stimulus (70-91% for right-facing E and 67-96% for one bar) were close to, but not consistently above the criterion (sessions 7-10).

Easel Movement: Correct responses to the right-facing E did not change. Correct responses to the one bar decreased from 96% (session 11) to 59% (session 14). After easel movement was discontinued (sessions 19-34), correct

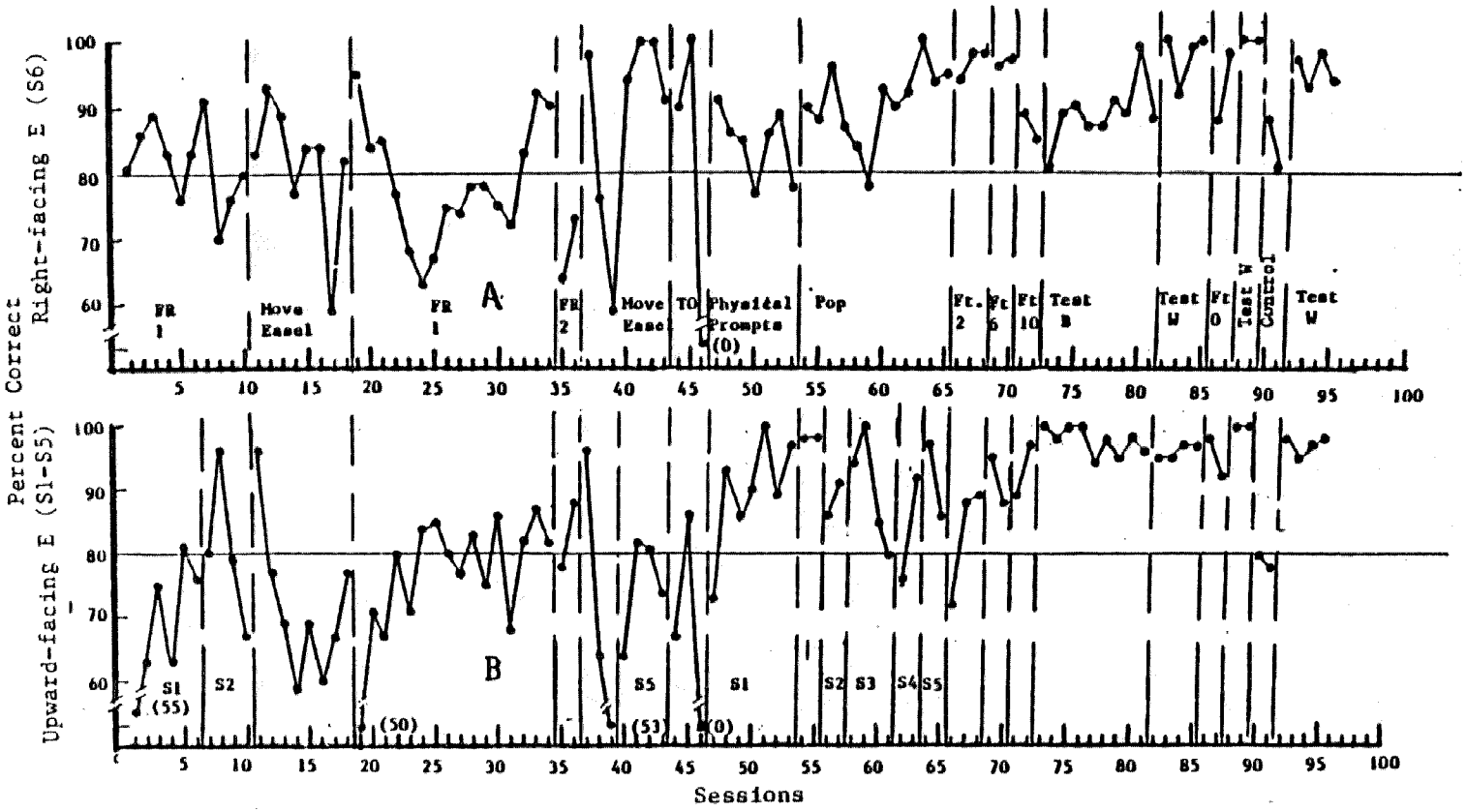

Figure 2. Training and testing data for Participant 1 are shown. The ordinate in the top panel (A) of the figure is the percent of correct responses to the right-facing E (S6); the ordinate in the bottom panel (B) of the figure is the percent of correct response to the faded upward facing E (S1-S5). The horizontal lines show the criterion of 80% correct responses. The vertical phase lines separate experimental conditions. Experimental conditions are specified in panel A; the stimulus card number (see Figure 1) is specified in panel B. Sessions are plotted on the abscissa.

responses to the right-facing E decreased below the criterion and remained low. Correct responses to the one bar gradually increased to the criterion by session 22. During sessions 32-34, correct responses during both stimuli remained above the criterion for three consecutive sessions for the first time.

Reinforcement Schedule: The reinforcement schedule was increased on session 35 to avoid satiation. Correct responses to the right-facing E decreased from 90% to 64%, but remained near the criterion (78-88%) to the one bar.

Easel Movement: Correct responses in the presence of both stimuli decreased below 60% in session 39. In sessions 40-43, correct responses to the right-facing E varied from 91-100%, but correct responses to the one bar decreased from 82% to 74% (see Figure 2).

Upward-facing E (S5) Probe: Since correct responses to either the right-facing E or the upward-facing E were above the criterion in sessions 41 and 42, the upward-facing E continued to be presented. Correct responses to the right-facing E and to the upward-facing E varied from 91-100%, and 65-82%, respectively (sessions 40-43).

Time-out: Since correct responses to the upward-facing E remained below the criterion, a time-out (TO) procedure was implemented in session 44. Participant 1

virtually discontinued responding by session 46; he held his hand over a lever, without pressing it.

Physical Prompts and Blank Card (S1): The upward-facing E was replaced with the blank card. The experimenter physically prompted the participant to respond to the lever he held his hand over. Correct responses to the right-facing E and to the blank card varied from 77-91% and 72-100%, respectively.

Pop: Correct responses to each stimulus varied from 88-98% (sessions 54 and 55). Correct responses to the blank card remained above 86% for eight consecutive sessions (sessions 54-61).

Fading the Upward-facing E (S5): When the one bar was introduced in sessions 56 and 57, correct responses remained above the criterion. When two bars were introduced (sessions 58-61), correct responses to the right-facing E first decreased to 78%, then increased to 93% and 94% but correct responses to the two bars decreased to 85% and 80%. When the three bars were introduced (sessions 62 and 63), correct responses to the right-facing E were 92% and 100% and to the three bars were 76% and 92%. When the upward-facing E was introduced (sessions 64 and 65), correct responses to the right-facing E were 94% and 95% and to the upward-facing E were 97% and 86%.

Distance Training

The distance between the participant and the easel was increased to 2, 6, and 10 feet in sessions 66-72. Correct responses to the right-facing E varied from 85-98% and correct responses to the upward-facing E varied from 72-97%.

Testing Results for Participant 1

Testing Between Sessions (Test B)

Test B was completed in nine sessions with Participant 1. When the stimuli were reduced one size per session (sessions 73-81), correct responses to the right-facing E varied from 81-99% and to the upward-facing E varied from 94-100%. Figure 2 (A and B, sessions 74-81) shows little variability in correct responses to each stimulus.

Testing Within Sessions (Test W)

Test W was completed in sessions 82-85, 88-89, and 92-95. Correct responses to the right-facing E varied from 92-100% and to the upward-facing E varied from 95-100%.

Reversal to Training Conditions

The 10/800 Es were presented at ten feet in sessions 86-87 due to the difficulty in maintaining correct responses when the smaller sized stimuli were presented in the Test W (see Figure 3). Correct responses to the right-facing E and to the upward-facing E varied from 88-98% and

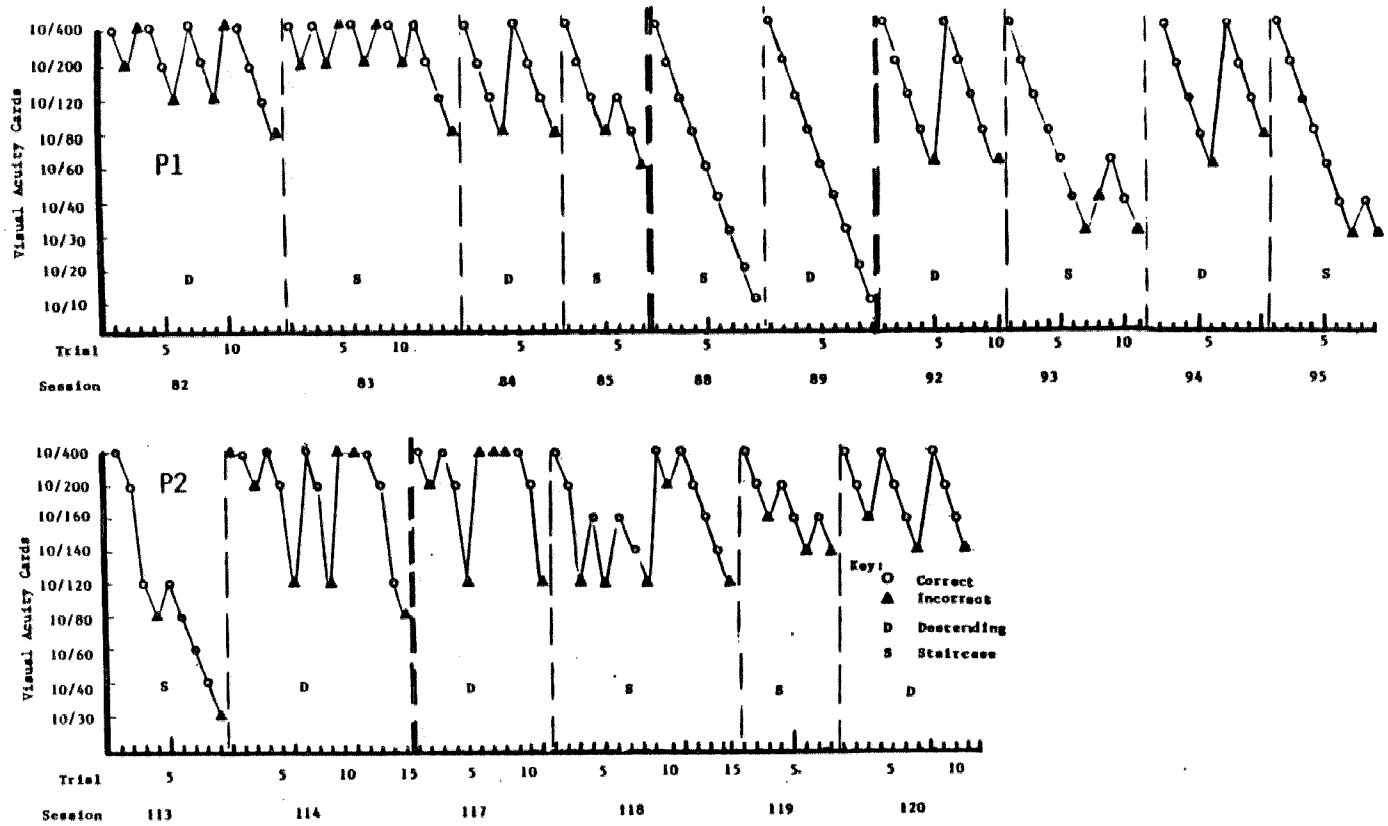

Figure 3. The threshold data from the testing procedures for Participant 1 (top panel) and 2 (bottom panel) are shown. The ordinates are visual acuity ratios of the stimulus cards. The abscissas are trials. Phase lines divide the trials into sessions with one stimulus presentation method used per session. Descending series (D) and Staircase (S) methods are shown. Double phase lines separate successive tests. Open circles represent correct responses and closed triangles represent incorrect responses.

92-98%, respectively (see Figure 2).

Control Cards

Correct responses in sessions 90-91 decreased to both stimuli (78-88%).

Threshold Testing Results (Test W) for Participant 1

Threshold tests were conducted in sessions 82-85, 88-89, and 92-95. The descending series method was used in sessions 82, 84, 89, 92, and 94; the staircase method was used in sessions 83, 85, 88, 93, and 95. The top panel of Figure 3 shows the threshold testing results from Test W for Participant 1.

In sessions 82 and 83, the smallest stimulus in which Participant 1 responded to correctly was the 10/120 E. Correct responses were difficult to maintain as reflected by the frequent errors to the larger stimuli. When using the descending series method (session 84), Participant 1 responded correctly until the 10/120 E. When the staircase method was used (session 85), Participant 1 responded correctly until the 10/60 E, the lowest thus far.

In sessions 88-89, Participant 1 responded correctly to all the various sized Es (see Figure 3). Neither stimulus presentation method was actually used due to no errors occurring.

The smallest sized E in whicn Participant 1 responded correctly with the descending series method (sessions 92 and 94) was the 10/60. Participant 1 responded correctly

to the smaller E (10/30) during the staircase method (sessions 93 and 95).

Training Results for Participant 2

Pretraining

Data were not collected during pretraining.

Discrimination Training

Discrimination training required 69 sessions.

Right-facing E (S6) versus Blank Card (S1): Correct responses to the right-facing E and to the blank card varied from 62-86% and 70-79%, respectively (sessions 1-4).

Right-facing E (S6) versus One Bar (S2): Correct responses to the right-facing E varied from 79-96% (sessions 5-11). Correct responses to the one bar varied from 61-88% with a variable trend (see Figure 4B).

Upward-facing E (S5) Probe: Correct responses to the right-facing E remained within 72-87% with a decreasing trend and to the upward-facing E varied from 67-87% (sessions 12-19).

Right-facing E (S6) versus One Bar (S2): The one bar was again introduced (sessions 20-22) due to the decreasing trend in the presence of the right-facing E. Correct responses to the right-facing E increased to 87% (session 20), but decreased to 72% (session 22). Correct responses to the one bar remained stable from 80-88%.

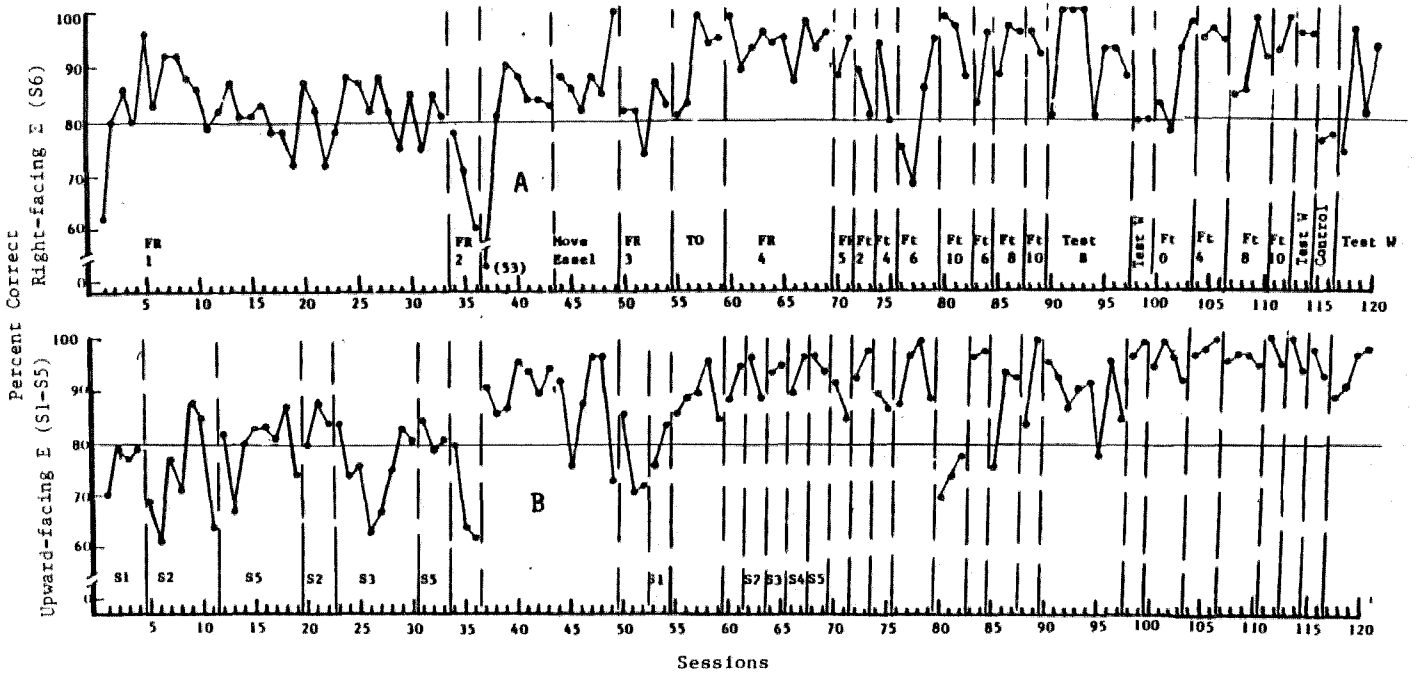

Figure 4. Training and testing data for Participant 2 are shown. The ordinate in the top panel (A) of the figure is the percent of correct responses to the right-facing E (S6); the ordinate in the bottom panel (B) of the figure is the percent of correct responses to the faded upward-facing E (S1-S5). The horizontal lines show the criterion of 80% correct responses. The vertical phase lines separate experimental conditions. Experimental conditions are specified in panel A; the stimulus card number (see Figure 1) is specified in panel B. Sessions are plotted on the abscissa.

Right-facing E (S6) versus Two Bars (S3): Correct responses to the right-facing E remained stable from 75-88% and to the two bars varied from 63-84% with a decreasing trend in four sessions and an increasing trend in the remaining four sessions (sessions 23-30).

Upward-facing E (S5) Probe: Correct responses to the right-facing E and the upward-facing E varied from 75-85% and 79-84%, respectively (sessions 31-33). Correct responses to each stimulus reached the criterion, but was not consistently above it.

Reinforcement Schedule: Correct responses to the right-facing E and to the upward-facing E decreased significantly within three sessions (sessions 34-36). Correct responses to the right-facing E varied from 62-78% and to the upward-facing E varied from 62-80%.

Easel Movement: Correct responses to the right-facing E increased to above the criterion for twelve consecutive sessions and varied from 53-100% (sessions 34-49). Correct responses to the upward-facing E immediately increased to 91% (session 39) and varied from 76-97% (sessions 37-49).

Reinforcement Schedule: Correct responses to the right-facing E varied from 76-87% and to the upward-facing E decreased from 86% to 71% (sessions 50-54).

Right-facing E (S6) versus Blank Card (S1): The blank card was introduced again (session 53) due to the

decrease in correct responses to the upward-facing E. Correct responses increased to 76-84% (sessions 53-54).

Time-out: Correct responses to the right-facing E and to the blank card varied from 81-100% and 85-99%, respectively (sessions 55-59). After the implementation of time-out (session 55), correct responses to each stimulus increased to well above the criterion.

Reinforcement Schedule: Correct responses to each stimulus remained above the criterion (sessions 70-71).

Fading the Upward-facing E (S5): The upward-facing E was entirely displayed within seven sessions (sessions 62-68). Correct responses to the right-facing E varied from 87-98%. Correct responses during the gradually faded upward-facing E varied from 89-97%. The criterion was met during the entire procedure.

Distance Training

The distance between the participant and the easel was increased to 2, 4, and 6 feet. At 6 feet, correct responses to the right-facing E decreased below the criterion (sessions 76-77), then increased to 86% and 95% (sessions 78-79). At ten feet (sessions 80-82), correct responses to the right-facing E remained stable between 88% and 99%, but correct responses to the upward-facing E significantly decreased to 70-78%. When the distance was decreased back to 6 feet (sessions 83-84), correct responses to each stimulus recovered to above the criterion.

When the distance was increased to 8 feet (session 85), correct responses to the upward-facing E decreased to 76% (session 85), but then increased to 94% and 93% (session 86 and 87). At ten feet (sessions 88 and 89), correct responses to the right-facing E and to the upward-facing E varied from 92-96% and 84-100%, respectively. Since correct responses to both stimuli remained above the criterion, testing was initiated.

Testing Procedures for Participant 2

Testing Between Sessions (Test B)

Test B was completed in 8 sessions. When the stimuli were reduced one size per session (sessions 90-97), correct responses to the right-facing E and to the upward-facing E varied from 81-100% and 78-96%, respectively. Figure 4 demonstrates the variability in the data during Test B.

Testing Within Sessions (Test W)

Test W was conducted in sessions 98-99, 113-114, and 117-120. Correct responses to the right-facing E varied from 74-100% and to the upward-facing E varied from 89-100%.

Reversal to Training Conditions

After the easel was moved to the center of the console (sessions 100-103), correct responses to the right-facing E and to the upward-facing E varied from 78-97% and 93-100%, respectively (see Figure 4). The easel was moved to 4, 8,

and 10 feet in sessions 104-112. At 4 feet (sessions 104-106), correct responses to the right-facing E and to the upward-facing E varied from 94-96% and 97-100%, respectively. At eight feet (session 107-110), correct responses to the right-facing E and to the upward-facing E varied from 84-91% and 95-97%, respectively. At ten feet (sessions 111-112), correct responses to the right-facing E and to the upward-facing E varied from 92-98% and 95-100%, respectively.

Control Cards

Correct responses to the control card in the first and second positions varied from 76-77% and 93-98%, respectively (sessions 115-116). Correct responses to the control card in the first position was below criterion during both sessions.

Threshold Testing Results (Test W) for Participant 2

Test W was conducted in sessions 98-99, 113-114, and 117-120. The staircase method was used in sessions 98, 113, 118, and 119; the descending series method was used in sessions 99, 114, 117, and 120. The bottom panel on Figure 3 shows the threshold testing results with Test W for Participant 2.

The threshold data for sessions 98-99 are not displayed on Figure 3 due to correct responses to the right-facing E occurring just at criterion (see Figure 4A).

In sessions 113-114, the smallest stimulus that Participant 2 responded to correctly with the staircase method (session 113) was the 10/30. The smallest stimulus that Participant 2 responded to correctly with the descending series (session 114) was the 10/80. In sessions 117-120, the smallest stimulus that Participant 2 responded to correctly with the descending series method (sessions 117 and 120) was the 10/120 and 10/140, respectively. With the staircase method (sessions 118 and 119), the smallest stimulus that Participant 2 responded to correctly was the 10/120 and 10/140, respectively.

Phase I Training Results for Participant 3

Pretraining

Data were not collected during pretraining.

Discrimination Training

Discrimination training in Phase I required 19 sessions.

Right-facing E (S6) versus Blank Card (S1): Correct responses to the right-facing E and to the blank card occurred at 33% and 43%, respectively (session 1).

Stimulus Presentation Interval: After an increase in the stimulus interval from thirty seconds to two minutes (session 2-3), correct responses varied from 82-85% and 51-56% to the right-facing E and to the blank card, respectively. When the stimulus interval was reduced to one minute (session 4), correct responses to the right-

facing E declined to 72%, while correct responses to the blank card remained stable at approximately 52%. Correct responses to the right-facing E demonstrated an increasing trend in sessions 5-8 (see Figure 5). The higher rate on one lever indicates that Participant 3 may have developed a preference for the right-hand lever.

Reinforcer Revisions: The edible reinforcer was changed from M&Ms to jelly beans due to stable low percentages of correct response to the blank card (session 9-11). This alteration had minimal effect for correct responses to the right-facing E continued to vary from 79-95% and to the blank card increased slightly to 57-65%. When the edibles were reversed to M&Ms (session 12-16), correct responses to the right-facing E and to the blank card varied from 71-96% and 41-56%, respectively. Correct responses to the blank card decreased slightly, but basically remained at approximately the same level as in previous conditions (see Figure 5).

When praise was included (sessions 17-19), correct responses to the right-facing E remained at 88-97%, but correct responses to the blank card decreased to 41-56%.

Phase I Training Summary: Overall, correct responses to the right-facing E and to the blank card varied from 33-96% and 41-68%, respectively. Correct responses to the blank card were not above the criterion in any procedure (sessions 1-19).

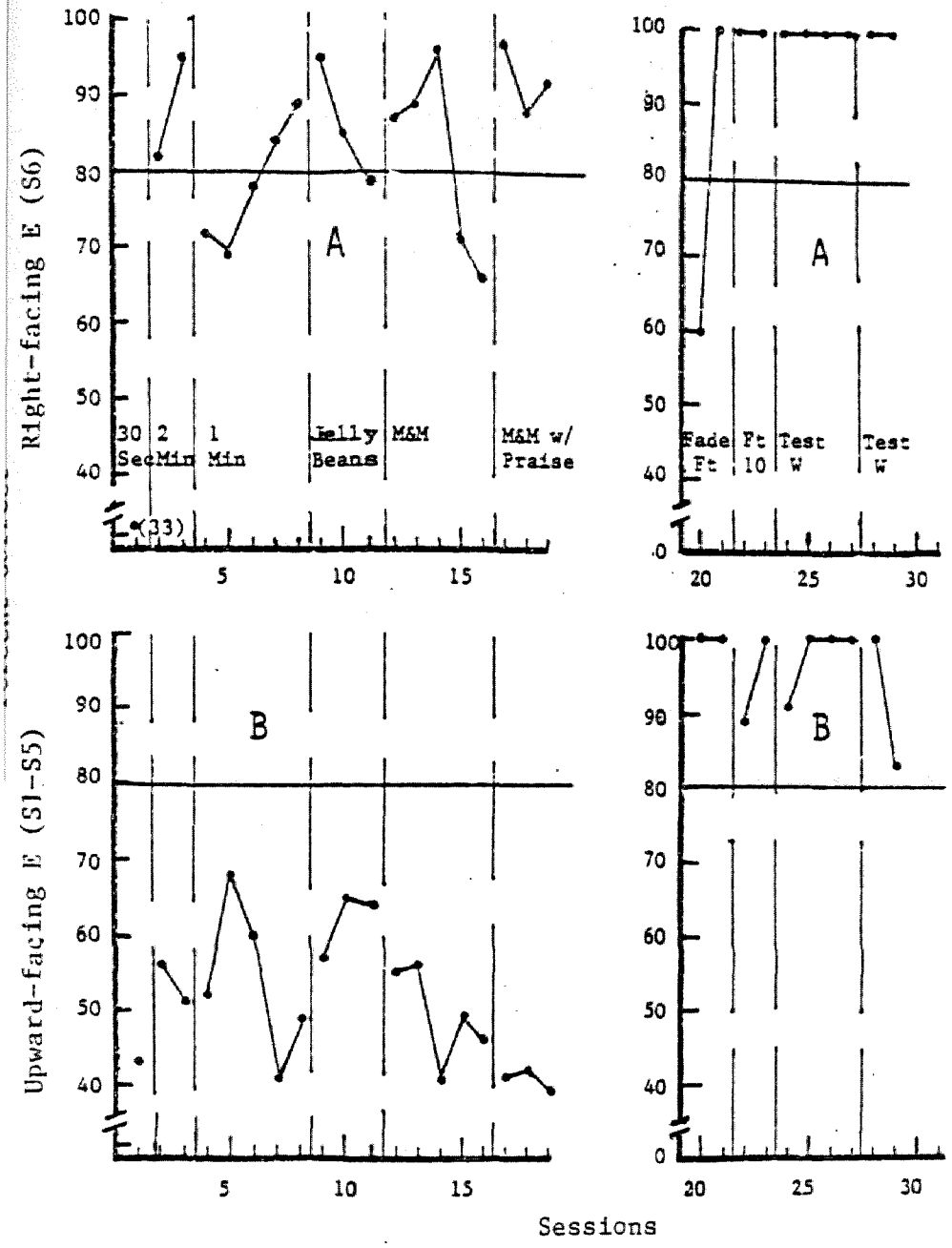

Figure 5. Training and testing data for Participant 3 are shown. The ordinate in the top panel (A) of the figure is the percent of correct responses to the right-facing E (S6); the ordinate in the bottom panel (B) of the figure is the percent of correct responses to the faded upward facing E (S1-S5). The horizontal lines show the criterion of 80% correct responses. The vertical phase lines separate experimental conditions. Experimental conditions are specified in panel A; the stimulus card number (see Figure 1) is specified in panel B. Sessions are plotted on the abscissa.

Difficulties in obtaining stimulus discrimination resulted in a referral for an educational evaluation. The participant was identified as capable of drawing complex symbols and was requested to draw a right-facing E and an upward-facing E, as each card was successively presented. Since he completed the task accurately, lever pressing was replaced by a drawing response within Phase II.

Phase II Training Results for Participant 3

Phase II was completed in nine sessions.

Discrimination Training

Right-facing E (S6) versus Upward-facing E (S5):

Discrimination training was completed within two sessions. The participant responded correctly 60% and 100% to the right-facing E and to the upward-facing E, respectively (session 20). The participant responded correctly 100% to each stimulus (session 21).

Distance Training

When the distance increased (session 22), the participant responded correctly 100% and 89% to the right-facing E and to the upward-facing E, respectively. At ten feet (session 23), the participant responded correctly 100% to each stimulus.

Testing Results for Participant 3

Threshold Testing

Participant 3 made an error on the 10/60 sized E (session 24). On the three subsequent testing sessions

(sessions 25-57), the participant responded correctly 100% of the trials. The participant responded correctly 100% to the right-facing E and to the upward-facing E (session 28). In session 29, the participant responded correctly 100% to the right-facing E, but responded correctly 83% to the upward-facing E. The errors occurred during the 10/80 and 10/30 sized Es.

Training Results for Participants 4 and 5

Pretraining

Data were not collected during pretraining.

Discrimination Training

Discrimination training was conducted within five trials for each participant. Participant 4 made four errors within one trial and Participant 5 responded correctly during all five trials.

Testing Results for Participants 4 and 5

Participant 4 responded correctly in the presence of all visual acuity cards in both testing sessions. Participant 5 made an error in the presence of the 10/80 sized E (session 2) and responded correctly to all the remaining Es.

CHAPTER IV

DISCUSSION

The present study assessed the visual acuity of three profoundly retarded individuals using a forced choice paradigm and investigated two variations in stimulus presentation methods commonly used in psychophysical research. Extensive training and several procedural alterations were required to obtain stimulus control. The researcher needed to be flexible and sensitive to possible procedural alterations that became necessary for each participants' progress.

Once response accuracy was maintained above the criterion, the visual acuity assessments were conducted. For Participants 1 and 2, the threshold crossings varied significantly within and across tests. The staircase method resulted in lower or the same threshold crossings during Test W. This result is consistent with previous literature (Springer, 1980; Woolcock & Alferink, 1982). Reliable threshold estimations could not be specified for Participants 1 and 2 due to the variable threshold crossings obtained within and across tests.

Training Procedures

Several procedural alterations and an extensive period of time was required to obtain stimulus control. The initial discrimination between the right-facing E (S6) the blank card (S1) was difficult to achieve. Response

accuracy was maintained above the criterion only after the time-out was implemented. The training times for Participants 1 and 2 were approximately 24 and 30 hours, respectively. The training time required in the previously cited studies varied from two to six hours (Macht, 1970, 1971; Newsom & Simon, 1977; Springer, 1980; Woolcock & Alferink, 1982).

Several factors may have influenced the difference in training time between the present study and the prior studies. First, instructions and time-out were not implemented until approximately midway in the study. The time-out procedure also involved instructions at the beginning of each trial ("Look at the card."). A possible interaction between instructions and time-out was not empirically assessed in this paper. A hypothesis that the verbal instructions enhanced the probability that the participants were attending to the stimuli can only be speculated. Secondly, the present study included several experimental conditions that were not included in the other studies; e.g., testing between sessions, and distance training. Third, the other studies included procedures that may have acquired the participants' attention to the stimuli. Finally, visual discriminations may be more complex than auditory discriminations, requiring more extensive training.

Since visual discriminations are complex, the

researcher should look for the simplest procedure. In past studies, the procedures were adapted several times throughout (Meyerson & Michael, 1960; Sidman & Stoddard, 1966). As stated in Sidman and Stoddard (1966, p. 185): "By constantly revising the program, we were able to eliminate consistent errors that kept the children from progressing." This was the most significant for Participant 3 whose basic writing skills were incorporated into a response requirement for assessing his visual acuity. The main objective of the present paper was to devise a simple and easily administered procedure for assessing the visual acuity of the profoundly retarded. To accomplish this goal, the researcher must be willing to adapt the procedures to the participant's skills.

Threshold Testing

The threshold tests were completed using the descending series and the staircase method of stimulus presentations. Although the response patterns differed minimally between the two stimulus presentation methods, the staircase method was more likely to result in lower threshold crossings than the descending series.

The first two threshold tests for Participants 1 and 2 did not achieve low threshold crossings. These testing sessions were conducted after testing between sessions (Test B). The smallest E (10/10; 20/20) was presented in the last Test B session (session 81) which may have

weakened stimulus control in the following sessions of Test W when the 10/400 card was used.

The lowest threshold crossings for both participants were obtained in the sessions immediately following the reversal to training conditions. Overall, the lowest stimulus to which Participant 1 responded correctly varied significantly from session to session. A threshold estimation was not identified due to this variability. Participant 2 responded correctly to the larger sized stimuli with the exception of one session. The latest ophthalmology examination reported a diagnosis of mild esotropia. During the present procedures, Participant 2 deteriorated in correct responses during distance training. He was observed turning his head slightly to the left when looking at the stimuli from a distance.

While testing between sessions (Test B), Participants 1 and 2 were discriminating between the right-facing E and the upward-facing E above the criterion. Correct responses by Participant 2 decreased as the size of the stimuli decreased. Test B was not used as a threshold measure since testing within sessions (Test W) was more similar to traditional testing procedures.

Participant 3's visual acuity was estimated at 10/10 (20/20). The latest ophthalmology examination estimated his visual acuity at 20/30. The present procedures resulted in a lower threshold estimation.

Control Card

The control card presentations resulted in correct responses decreasing below the criterion on one lever. When the right-facing E and the upward-facing E were reinstated, correct responses recovered to previous rates. The control card data support the notion that the participants were discriminating on the basis of the Es and not on some unknown, extraneous variables.

Comparison of Operant Procedures with Traditional Snellen Chart

Participant 4 responded correctly through the 10/10 (20/20) testing card. The results were consistent with those obtained by the ophthalmologist. Although Participant 5 made one error, his visual acuity may be estimated at 10/10 (20/20). The ophthalmologist obtained 20/25 visual acuity with the Snellen chart. The present results indicated slightly lower or the same threshold estimations as those with the traditional Snellen chart. Similar results were obtained by Newsom and Simon (1977) in comparing similar operant procedures with results from a Snellen chart. This difference may be attributed to the leg orientations of the E. These operant procedures used only two orientations (right-facing and upward-facing), while the Snellen chart uses four orientations (downward-facing, upward-facing, left-facing and right-facing).

Future Directions

In the present study, the importance of instructions versus time-out was not empirically verified. Future research, investigating these two independent variables, may be indicated.

Subjective observations indicate that the main obstacle in obtaining the initial discrimination (right-facing E versus blank card) was focusing the participants' attention to the stimuli. Procedures for testing visual acuity in the profoundly retarded population must include a means to promote attention. This may be accomplished using a procedure from the literature or by novel means. Previous research used instructions (Newsom & Simon, 1977), chimes paired with visual stimuli (Sidman & Stoddard, 1966), and card illumination (Macht, 1970, 1971). The stimuli may be presented via computer with the joystick as the operandum. The size of the Es may be adjusted easily for the different visual angles. A computer may reduce the participants' visual field and distractions, ensuring attention to the stimuli.

Future research investigating tests between sessions should be completed. Profoundly retarded may not be able to maintain responding when the stimuli are changed quickly, requiring testing over several sessions.

In summary, the present procedures must be further refined before application to the applied setting due to

the extended time in training and variable threshold crossings obtained with two participants. Instructions and time-out appeared to be significant variables in obtaining stimulus control. The researcher was required to adapt the procedures several times to obtain participant progress.

Reliable threshold estimations were obtained with three participants. These threshold estimations were lower or the same as those obtained by an ophthalmologist using the traditional Snellen chart. The threshold crossings produced with the staircase method were similar to or lower than those produced with the descending series method. Future research should investigate the significance of simple instructions and time-out, testing between sessions (Test B), and computerizing refined testing procedures.

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APPENDIX A

Visual Acuity Assessment Tasks

APPENDIX A

Visual Acuity Assessment Tasks

Basically, four different tasks are available for assessing visual acuity; detection, direction, resolution, and recognition.

In detection tasks, the observer identifies the presence or absence of a given stimulus in the visual field. Typically, the stimulus is a single line which is reduced in width in successive presentations. The most narrow line detected by the observer indicates the visual acuity measurement. This task provides the finest index of visual acuity, about 1/2 second of arc.

Directional tasks involve the observer being able to discriminate the displacement of one element in the visual field. Generally, this is accomplished by presenting a single line which may have a slight displacement to the side. The observer indicates whether the line is continuous or has a sideways displacement. The smallest detectable displacement in the line indicates visual acuity. The minimum visual acuity obtainable with this task is approximately two seconds of an arc. Directional tasks are most significant in identifying binocular displacement between the two eyes.

Resolution tasks require the observer to indicate the separation between elements in a pattern. Typically, the tasks involve the presentation of line gratings in which

the width of the lines is equal to the space in between the lines. The gap between the lines are varied which changes the closeness of the lines. The observer indicates whether the lines are horizontal or vertical. The visual acuity measure is determined by the smallest detectable gap between the lines. The finest obtainable acuity measure is approximately thirty seconds of arc.

The last and most familiar visual acuity task is recognition. Recognition tasks assess the observer's ability to recognize and name symbols or letters. Each symbol or letter is constructed so that the thickness of the line is 1/5 the height of the symbol. The letters or symbols are presented to the observer in progressively smaller sizes. The smallest letter or symbol recognized determines the visual acuity measurement. The finest obtainable acuity is approximately 30 seconds of arc. Recognition tasks are not as sensitive a measure of visual acuity as the others mentioned above, "but is much easier to administer and standardize, and is probably more relevant for the practical uses of visual acuity" (Harber & Hershenson, 1973, p. 115).

Visual acuity is typically specified as a fraction with the numerator representing the standard distance from the symbol to the observer and the denominator representing the minimum visual angle perceived by the observer. The standard for normal visual acuity is 20/20 which means the

observer recognized a symbol whose line segments subtend one minute of arc at a distance of 20 feet. Hence, a visual acuity of 20/10 would indicate the recognition of line segments subtending 0.5 minutes of arc and 20/400 would indicate the recognition of line segments subtending 20 minutes of arc.

A variety of tests using various letters and symbols have been developed to assess visual acuity. In addition to the Snellen charts previously described, Hans Landolt developed a recognition task which uses circles with a gap. These circles have become known as the Landolt rings or Landolt C. The gap in the rings are oriented up, down, left, or right and the observer indicates the position of the gap. The rings are reduced in progressively smaller sizes, as the Snellen charts. The smallest detectable gap determines the visual acuity measurement.

In order to test young children, several modified versions of the Snellen recognition tasks have been developed.

These variations include providing the observer with a cardboard E in which the individual places it in the same position as the sample displayed on a cube. A similar variation contains a movable E in the center of four simple pictures. The center E can be turned so that the legs may point to each picture. The observer indicates at which picture the legs are pointing from various distances.

Other tests involve cut-out symbols that the observer matches with similar objects that are at a distance. The symbols that are used are familiar to the observer.

Test cards with hands that had the fingers spaced equivalent to the illiterate E chart were developed by Sjogren (1939). The procedure for measuring visual acuity was the same as that for the illiterate E chart.

There are numerous other examples of modified tests in which to examine young children. All of the tests require that the clients understand complex instructions involving direction or picture recognition. This does not always include the profoundly retarded.

APPENDIX B

Response Requirements

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In psychophysical research, the response requirements may involve the use of single or multiple response operandums.

Single Response Requirement Methods

The two frequently employed single response techniques are the conditioned suppression and "go-no-go" methods.

In the conditioned suppression method, the participant is reinforced for responding on a single operandum. Once responding is stabilized, a neutral stimulus is presented (i.e., tone). At the end of the neutral stimulus presentation, an aversive stimulus is presented. After several pairings of the neutral/aversive stimuli, the onset of the neutral stimulus reduces or stops responding for the duration of the neutral stimulus.

To obtain threshold measures, the stimulus is altered along a specific dimension (i.e., tone intensity). The average level at which the stimulus presentations no longer suppress responding represents the participant's threshold. Rats were trained to lick a tube through which secreted a sugar-milk solution (Ray, 1970). Once responding was stable, a brief tone which ended with an electric shock was presented. Responding during the tone decreased through this pairing with shock. Because of the use of aversive stimuli (i.e., shock), ethical restrictions

are imposed in the application of this method with the retarded population.

In the "go-no-go" method, the participants are reinforced for responding on an operandum in the presence of a given stimulus. Responses in the absence of the stimulus are followed by extinction or punishment procedures (i.e., brief time-out, verbal reprimand). Using the "go-no-go" method, Fulton and Spradlin (1974) and Woolcock and Alferink (1982) trained profoundly retarded participants to respond on a key during brief tone presentations. Auditory thresholds were obtained by reducing the tone intensity. The tone intensity at which responding was greatly reduced represented the threshold. Both studies reported difficulties in maintaining stimulus control over responding.

Two major disadvantages of single response requirement procedures were cited by Blough and Blough (1977). The occurrence of reinforcement in the S^D condition (stimulus presentations) may serve as a cue for responding and the occurrence of reinforcement in the S^D condition may reinforce responses in the preceding S^Δ condition. As the difference between the S^D and S^Δ conditions are reduced, the effects of the reinforcement schedules on false-positive responses increases. Subjects will continue to respond in the absence of the stimulus as this response has been reinforced in the past. This response bias may occur

because of the lack of an alternative response during the S^{Δ} condition.

Multiple Response Requirement Methods

The multiple response methods reduce this response bias by providing an alternative response during the S condition. When assessing human sensory thresholds, the participant is provided with at least two responses on each trial, (i.e., yes, no; left, right; up, down). Therefore, the use of two or more responses approximates the responses made in traditional sensory threshold testing in the human population.

The two methods which use two or more response operanda are response chaining and multiple schedule of reinforcement methods. Within the response chaining method, responses to one operandum result in a stimulus change. Responses to the second operandum, after the stimulus change, result in reinforcement. Visual thresholds in pigeons were obtained using the stimulus offset response chaining method (Blough, 1958). The pigeon pecked key A when the stimulus was visible and key B when the stimulus was dark. Pecks on key A turned the stimulus off while pecks on key B produced food. An alternative is the stimulus onset response chaining method. A tone onset method was used to obtain auditory thresholds in monkeys (Stebbins, 1970b). Responses on lever A turned the tone on while responses on lever B during the tone resulted in

food. The major difficulty with response chaining methods is that reinforcement follows only one response. The second response serves as an observing response which produces a stimulus change. A high rate of false-positive responses to reinforced responses and switching between responses in rapid succession was found by Stebbins (1970b). To alleviate this problem, Stebbins (1970b) imposed a limited hold response requirement. The pigeons were required to respond to key B within 5 seconds or the tone trial was lost. This alteration greatly complicates the response chain method.

Within multiple reinforcement schedules, the participant is required to make one response in the presence of one stimulus and a different response in the presence of a second stimuli. A successive discrimination training procedure is utilized in that one stimulus is always present. A multiple schedule of reinforcement was used in audiological discrimination training with normal and retarded children (Meyerson and Michael, 1960). Responding on the "tone-on" key during the tone interval and responding on the "tone-off" key during the no tone interval was reinforced on a multiple VR4 VR4 schedule. Each stimulus condition was in effect on the average of every two minutes. Obtaining reliable threshold measurements was difficult due to the participants slowly switching responses when the stimulus changed.

The forced choice paradigm combines some features of the one key trial-wise and the two key continuous procedures. In the forced choice procedure, two or more responses are controlled by a different stimulus. According to Blough and Blough (1977), the two-response forced choice method has been used extensively within visual psychophysics. A forced choice paradigm by Springer (1980) involved the reinforcement of left hand key presses in the tone-on trial and right hand key presses in the tone-off trial. An intertrial interval of 10-15 seconds followed each trial in training and testing sessions. An observing response is often added to the forced-choice method (Blough, 1971). The responses on the observing key illuminated two stimuli (strips or blank) which were displayed at the opposite end of the experimental chamber. Responses on the key with the strips resulted in reinforcement, while responses on the blank key resulted in termination of the trial.

In a "yes/no" procedure responses on one operandum are reinforced in the presence of the stimulus and responses on the other operandum are reinforced in the absence of the stimulus. This procedure is used when stimuli must occur in succession, as in most auditory assessment tests. The above procedures, "although useful, differ in their suitability for particular sensory modalities in their ease of instrumentation, and very likely in their suitability

for particular species. Unfortunately, we are generally unable to say whether they also differ with respect to threshold measures that they yield" (Blough & Blough, 1977, p. 519). Furthermore, "the studies that make such comparisons are, however, difficult to interpret, since many aspects of each situation are chosen arbitrarily and effects of these parameters could obscure real methodological effects" (Blough & Blough, 1977, p. 519).

APPENDIX C

Methods of Stimulus Presentation

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Methods of Stimulus Presentation

Four techniques for obtaining sensory thresholds are available in psychophysical research; method of constant stimuli, method of adjustments, method of limits, and the staircase method (Stebbins, 1970a).

In the method of constant stimuli, a fixed set of stimulus values, chosen by the experimenter, are presented to the participant in a randomized order. The threshold is obtained from the probability with which the participant reports each stimulus value.

The method of adjustment involves presenting the participant with a range of stimuli within one trial. The participant identifies the stimulus value that is just discriminable. The threshold is some measure of the tendency to identify certain stimulus values over several trials. Therefore, the threshold is specified according to the participant's choice within the range of stimulus values. The major disadvantages of the method of adjustment are sequential effects, no control on rate of stimulus presentations by experimenter, and the requirement that the participant understands complex instructions.

In the method of limits, the experimenter presents a stimulus at one extreme of the stimulus value. Over sequential trials, the stimulus value is changed toward the other end of the range in predetermined steps of stimulus

values until a change occurs in the participant's responses. An ascending series is when the stimulus difference is increased over several trials; while in the descending series, the stimulus difference is decreased over trials. Several studies have compared thresholds obtained with both ascending and descending series. Ascending method of limits was found to produce slightly lower threshold value, but a greater tendency to respond in the absence of a signal (Dalland, 1970). Another study found that ascending series produced higher thresholds than the descending series (Terman, 1970). Similar thresholds were obtained with ascending and descending series of limits by Smith (1970). Therefore, the literature is not conclusive as to which method is the most advantageous. The major disadvantage of the method of limits is the sequential effects upon the participant's responses which may be reduced by providing a counterbalance order, and averaging the results of both ascending and descending series (Blough, 1971).

Overall, the above-described methods involve much time and effort in presenting stimuli above the threshold and may have sequential effects. The staircase or tracking method reduces these disadvantages. Within the staircase method, the participant's responses control the order of stimulus presentations. Correct responses result in a decrease in the stimulus value, while incorrect responses

result in an increase in the stimulus value. Therefore, most stimuli presented will be near the threshold value.

The advantages of the staircase method are that errors automatically return the participant to a less demanding level and indicates whether the error is a result of an inadequate fading sequence. When a participant makes several errors on a given trial, it is evidence that the stimulus control has deteriorated and the fading sequence may need to be revised. This revision is important to threshold measurements for "errors create more errors" (Terrace, 1963; Sidman & Stoddard, 1966). Once the fading procedure has been revised, further progress may occur.

The disadvantage of this procedure is the gradual loss of stimulus control for some participants. Reinforcement may occur in the absence of stimulus control by responses coming under the control of nonstimulus characteristics (i.e., schedule). This weakened stimulus control is enhanced by the progressive decrease in the stimulus value until it is below the threshold. Because approximately one-half of the stimuli will be subthreshold, the intertrial interval increases and, thus, reduces the rate of reinforcement and weakens stimulus control (Harrison & Turnock, 1975). To overcome this problem, Harrison and Turnock (1975) introduced the self-correcting and constant reinforcement rate procedures. The self-correcting procedure involves the increase in stimulus value following

the second occurrence of a response in the absence of the stimulus. Therefore, both failure to respond in the presence of the stimulus and responding in the absence of stimulus presentations resulted in an increase in stimulus value. The constant-reinforcement rate was maintained by changing the VR schedule to a VR2 following a failure to respond in the presence of the stimulus.

Two studies compared audiological threshold values obtained using the descending series method of limits and the staircase method for profoundly retarded participants (Woolcock & Alferink, 1982; Springer, 1980). Both studies indicated that threshold values obtained with the staircase method were equal to or lower than thresholds obtained by the descending series method of limits (Woolcock & Alferink, 1982; Springer, 1980).